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WOOD SEATS FOR STADIUMS

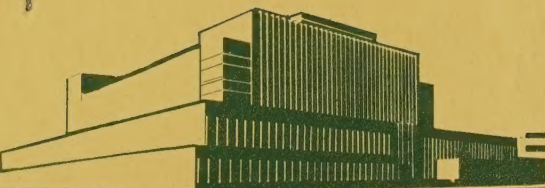
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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

In Cooperation with the University of Wisconsin

WOOD SEATS FOR STADIUMS

By

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U. S. Department of Agriculture

Wood is the material most widely used for seats in stadiums, grandstands, and bleachers. Information on the serviceability of wood when so used, obtained in a 1929 survey of 70 structures that were widely distributed geographically, is summarized in this report. Although most of these structures were comparatively new at the time of the survey, a number of useful conclusions were drawn.

Kinds of Wood.--Douglas-fir, redwood, and baldcypress were used for seats in 75 percent of the structures, with Douglas-fir in the majority. Other species included southern yellow pine, ponderosa pine, eastern spruce, oak, chestnut (not used at present), western larch, eastern fir, and pine (species not indicated). The record shows Douglas-fir was used for 26 structures in 16 States, redwood for 13 structures in 9 States, and baldcypress for 12 structures in 10 States.

Grades of Wood.--Yard lumber, which is the class used for seats, is divided mainly into Select and Common grades, the Select grades admitting only a few small knots and other minor defects. Of 58 structures, 75 percent used Select lumber. Only a little trouble was reported with No. 1 Common lumber, and for some species this grade appears suitable where there is a solid substructure, such as a concrete stadium. With skeleton framing of steel or wood, lumber of a Select grade should be used, as severe personal injury may occur if a seat or footboard breaks.

The tendency of resin to bleed from knots and the difficulty of maintaining paint on knots makes the use of even No. 1 Common lumber doubtful with resinous woods. When used on nonresinous woods, the paint or other coating does not stay so well on the knots as on the clear wood. Knots of less than 1/2-inch diameter, however, do not usually cause trouble in either kind of wood.

Edge-Grain and Flat-Grain Lumber.--In most cases, both edge-grain and flat-grain lumber were used for seats, but, out of 55 structures, only 13 used edge-grain lumber. Edge-grain lumber shrinks and swells less with moisture changes than does flat-grain lumber. It also shows less cupping, warping, and checking, and splinters less, wears more evenly, and holds paint more satisfactorily.

¹Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Loosening and splintering in flat-grain boards can be reduced by laying them with the bark side up (fig. 1). The bark side also holds the paint better than the pith side. In this position, the boards have a tendency to become concave on top, but this can be prevented or lessened by keeping the top and edges well protected with paint or varnish.

Boards and Slat Seats.--Seats of single boards, mostly 2 inches thick and 8, 10, or 12 inches wide, were used in 72 percent of the structures, although 1-inch boards were used in a few cases. Slat seats sometimes had three slats, each 2 by 3 or 2 by 4 inches, or two 2- by 3-inch slats and one 2- by 4-inch slat. When the seats had four or five slats, each slat was 1-1/2 by 2 inches. Since front slats receive the hardest usage and most impacts, they should be not less than 2 by 4 inches and preferably 2 by 6 inches. The spaces between slats ranged from 1/8 to 3/4 inch.

Wide boards, when maintained in good condition, are more comfortable and generally cost less to buy and paint as compared to slat seats. On the other hand, slats properly supported and fastened will not check, cup, or twist so much as boards of the same quality. More breakage is likely with slats, but the cost of replacements is probably less with slats than with boards. Wide boards may hold water in pools, which is not only disagreeable but may contribute to decay especially at joints and holes. The upper edges of boards and slats are usually chamfered or rounded to improve drainage and reduce splintering and wear.

Decay.--Resistance to decay or rot of wood seats depends upon such factors as species, climatic conditions, type of construction, preservative treatment, and percentage of heartwood and sapwood, heartwood being the more resistant. Decay was reported in 14 of the 70 structures, in most of which both heartwood and sapwood were present. It is safe to say that the sapwood was an important factor in the decay. Under conditions favorable to decay, the heartwood of baldcypress and redwood is durable, while that of eastern spruce, eastern fir, and red oak is more susceptible to decay. In Douglas-fir, white oak, and western larch, the heartwood has intermediate resistance to decay. The heartwood of some pines also has intermediate decay resistance, but it is no longer practical to obtain such wood in quantity. In all species, the sapwood rots quickly under conditions favorable for decay.

Seat Supports and Fastenings.--The type of support and method of attaching the seats to it are important factors in the serviceability of the wood. In figure 2, sketches A to F and J show typical designs for concrete substructures, and sketches G, H, and K are applicable for steel or wood substructures. Through-bolts or screws are used in A, C, D, and G. In some stadiums surveyed, the heads of bolts or screws were countersunk and sealed with putty. As putty shrinks in drying, however, it may separate from the wood, break the seal, and permit the entrance of water, which usually cannot drain away and so causes decay and corrosion. In a concrete stadium in Massachusetts, seat boards were laid loosely on the concrete during the football season and then removed to storage.

Decay at seat fastenings and corrosion of fastenings were reported at four stadiums; in one, nails were used; in another screws were driven from the top; and in the others, through-bolts were used. Decay is more apt to occur at fastenings driven from the top than at those driven from the bottom, as in B and F of figure 2. Through-bolts may be more effective in holding power if the wood does not decay, but there are no complaints of loosening with fastenings driven from the bottom. Carriage bolts or elevator bolts, which have large, thin, rounded heads and are used without countersinking, appear to be the best form of bolt fastening. With few exceptions, the board seats are laid flat or level, but it is suggested that they be laid with a slight pitch downward to the rear to give quick drainage.

Joints and Contact Points.--Contact areas are vulnerable to decay and should be designed for drainage and ventilation. In sketch H of figure 2, the footboards butt together tightly and are in contact with the guardboard, but the design at K is better, as spaces are left between the members. In most installations, the ends of boards or slats butt together tightly, and sometimes the joints are puttied. Open spaces are left in some cases, and in a few instances scarf joints are used. It is desirable to leave at least three-eighths inch between slats or boards to enable any moisture absorbed through the end grain to evaporate quickly. Square ends are preferable to scarfed ends because of the smaller area of end grain exposed.

Protective Coatings.--Most of the structures had coatings of some kind, including coal-tar creosote, linseed oil, linseed oil and turpentine, cement-base paint, oil stain, shellac followed by paint, varnish, white lead paint, mixed-pigment paint, deck paint, and china wood oil. Renewal of the coatings ranged from 1 to 5 years or longer. Coal-tar creosote is the only one of these materials that can be depended upon to increase the decay resistance of wood seats, but oil stains that contain creosote may have a slight beneficial effect if a thorough brush or spray application is made.

Paint, varnish, and similar coatings are not effective against decay, and under conditions favorable to decay, wood treated with these coatings can be expected to last little if any longer than unprotected wood. In fact, the coated wood may decay even more rapidly if the coating prevents free drainage of water or retards the drying of moisture that has entered the wood. These coating materials, however, when maintained in good condition, will protect wood against weathering. Weathering is caused in part by repeated swelling and shrinking caused by moisture changes at or near the surface of the wood, while the interior remains at relatively uniform moisture content and volume, and in part by chemical changes resulting from the action of sunlight, air, and water on the surface layers of wood. This action results in a slow breaking down and wearing away of the surface fibers accompanied by raising of the grain, cupping, checking, cracking, splintering, and splitting.

In a Connecticut stadium, the seats, when erected, were treated with china wood oil. Later, a gray deck paint was used; and, at the time of the survey, a lead-and-oil paint was being applied every 3 years. None of these prevented weathering, no doubt because they were not renewed frequently enough, but an annual coating of lead-and-oil paint was proposed when the stadium was inspected. A 2-year painting program at a stadium in Colorado did not prove effective against weathering. Trouble reported in getting paint to stick was probably caused by early wearing of the paint from the summerwood bands rather than by original failure of the paint to adhere to the wood. Trouble with paint flaking and chalking was experienced in several stadiums. All these difficulties probably can be remedied by more frequent painting.

For wood seats, a good white lead paint or titanium-lead-zinc paint should give satisfactory protection from the weather. Frequency of application depends upon the wood species and climatic conditions, but in view of the severe service and exposure, it is recommended that, after the original 2- or 3-coat paint job, a single coat be applied annually, or at least biannually, to lessen warping, checking, and splintering.

Natural finishes provide much less protection for wood against weathering than paints and are not nearly so durable as paints. They are, therefore, much more expensive to maintain than paints, even on exterior wood surfaces that are subject to much less severe weathering and exposure than stadium seats. Accordingly, such finishes are suitable for use only on seats for interior service.

Preservative Treatment.--Treatment of seats by toxic preservatives was reported in only four structures; (1) pressure treatment with zinc chloride; (2) coating every other year with creosote, probably by brushing or spraying; (3) treatment with a colorless preservative, no details of which are furnished; (4) treatment with creosote, but no details given.² The first three structures had not been in service long enough when the survey was made to determine the effectiveness of the preservatives. The fourth was a small Massachusetts structure, the seats of which were said to be in good condition after 14 years' service because of the preservative treatment and the structural design, which permitted air spaces wherever possible.

In some cases, linseed oil or linseed oil and turpentine applied by brushing, dipping, boiling, or soaking were mentioned as preservative treatments, but neither of these materials is a wood preservative. Linseed oil has little or no toxicity to the fungi that cause decay; and, while turpentine is toxic, it is volatile and soon leaves the wood.

Preservative treatment is economical only if the annual maintenance charges for the treated seats are less than those for untreated seats. With boards of heartwood of a species with high resistance to decay, there would be little saving, if any, but with mixed heartwood and sapwood or with species of lower decay resistance, the increased life should effect appreciable savings in annual costs.

²Since this survey was made in 1929, there have been numerous installations of wood pressure treated with waterborne preservatives for stadium and other outdoor seats. Such treatments are covered by Federal Specification TT-W-571: Wood Preservative, Recommended Treating Practice.

Waterborne preservatives are better than creosote for this purpose, as they are scarcely noticeable after the water has evaporated. Creosote cannot readily be painted and is apt to bleed and so cause damage to clothing. Pentachlorophenol in solutions with light-colored volatile oil solvents or commercial water-repellent preservatives can also be applied by either pressure or nonpressure treatment. Superficial treatment by dipping, brushing, or spraying is not nearly so effective as pressure treatment. If first seasoned to remove water added during treatment, wood treated under pressure with waterborne preservatives can be painted, so that the salt will not damage clothing. Such treatment is estimated to cost from \$25 to \$50 per 1,000 board-feet. Wood treated with pentachlorophenol in suitable petroleum solvents or with water-repellent preservatives can be painted after removal of the residual solvent.

Slivering, Loose Grain, and Pitch.--Slivering occurred on both coated and uncoated seats. It can be avoided largely by keeping the paint or other coating in good condition. Apparently this was not done with the coated seats reported as slivering. Grain loosening, reported in a number of cases, is most likely to occur also on the corners of both edge-grain and flat-grain lumber and on the edges of edge-grain lumber. It is more likely to occur in species with pronounced alternate hard and soft bands, such as southern yellow pine, Douglas-fir, western larch, and baldcypress. It can be reduced or prevented by maintaining a good protective coating and by laying boards with the bark side up, except that edge-grain boards may be laid with either side up.

No trouble was reported with natural coloring matter that had leached from the wood.

Resin or pitch was found to have exuded at 17 structures. In one installation in Wisconsin, this was so extensive that 1/2-inch boards were screwed to the seat boards as a remedial measure. The remedy was not satisfactory, however, since the new thin boards warped badly. Of the species used for seats, only southern yellow pine, ponderosa pine, and Douglas-fir contain resin in appreciable amounts. If highly resinous species are to be used, the trouble caused by resin may be reduced in the following ways: (1) Use kiln-dried lumber or lumber treated with waterborne preservatives under pressure, as the temperatures reached during the treatment will bring the resin to the surface, where it hardens and may be removed by planing; (2) if such treated lumber is not used, reject pieces that are noticeably resinous or pitchy; or if they are pitchy on one side only, lay that side down.

When otherwise satisfactory boards are marred by the presence of a few pitch pockets, it is often possible to treat the pitch pockets in one of several ways to render them harmless. If the pitch is still soft and the pockets are not too deep, the pitch may be washed out by thoroughly sponging it with denatured alcohol. In another procedure that is sometimes used, the pitch is heated with a blowtorch to draw it out of the pockets without charring the wood. The hardened pitch is then scraped off and the pockets are washed with alcohol. One of the best methods is to chisel out the pockets or remove them with an electrically operated router, and then to patch the holes with a suitable plastic compound.

Unseasoned Wood.--The use of green or wet wood has resulted in grain raising, cupping, bowing, twisting, and checking of the boards and pulling of the fastenings. In a stadium in California, the cupping and grain raising were so bad that, after 3 years, it was necessary to plane the tops of the seats. The wood should be air dried or kiln dried to a moisture content suitable for local atmospheric conditions.

Paper-Overlaid Planks.--Paper-overlaid planks fabricated of resin-impregnated kraft paper glued to low-grade lumber can be used as stadium seat planks. An experimental 300-seat installation of overlaid planks at Camp Randall Stadium at the University of Wisconsin has remained in good condition after 3 years of service. Planks may be built up to desired width by edge gluing random-width strips together. With proper impregnation of paper and use of waterproof adhesives, a durable product can be made. Raised grain, slivering, and exudation of pitch are eliminated, and end checking is greatly reduced. Planking for bleachers that have open spaces beneath should be strong enough for the imposed loads, since the paper covering adds little to the strength. Because of the low grades of lumber that may be used, the cost of the overlaid planking may compare favorably with that of conventional planking of good grade.

Strength Properties.--The important strength properties of wood for seats are bending strength, stiffness, hardness, and shock resistance. The species rank in this respect is shown in table 1. The figures given apply only to clear wood. For other material, the strength would depend principally upon the defects present. Values are shown separately for longleaf and shortleaf pine, rather than an average for the species sold under the commercial name of southern yellow pine.

Breakage occurring at the edges of boards, as at some stadiums, is due probably to excessive overhang, large checks, or severely cross-grained lumber. Boards in which the grain deviates from straightness by more than 1 in 12 should be rejected. Overhang, as marked X on sketch A in figure 2, should be as small as possible.

Conclusions

The following general conclusions and suggestions are based on reports of 70 structures, on later experience, and on various tests and experiments at the Forest Products Laboratory supplemented by field experience and service records.

1. Edge-grain lumber will stay in place better, wear longer and more evenly, and hold paint better than flat-grain lumber, but it costs more than mixed edge- and flat-grain lumber. Its advantages must be weighed against its increased cost.
2. Flat-grain seat boards should be laid with the bark side up, as this side holds paint better, and there will be less slivering and grain loosening. The tendency of the upper side to cup can be reduced by keeping the seats covered with a good weather-resistant coating.

3. Unless the wood is given a preservative treatment, use an all heartwood grade or eliminate all sapwood pieces. In any species, the sapwood is of low resistance.
4. Renew protective coatings frequently enough to prevent serious weathering of the wood. A good white lead paint or mixed-pigment paint applied annually, or at least biannually, should give sufficient weather protection. Varnish and similar coatings usually must be renewed more frequently and cost more than paint. Neither paint nor varnish will prevent decay.
5. Design and build the structure so that water can drain quickly from all wood members, particularly at points of contact, and maximum ventilation is insured. Contact areas between wood members should be avoided wherever possible.
6. Chamfer or round the top edges of seat boards or slats to reduce wear and splintering and assist drainage.
7. Give the seats only a small overhang to reduce breakage. Eliminate boards with cross grain having a slope of more than 1 in 12.
8. Avoid pitchy or obviously resinous boards. Kiln drying or preservative treatment at high temperatures, followed by surfacing, is beneficial in reducing pitch exudation but does not always provide complete insurance against it.
9. Seat fastenings driven from the underside will reduce the decay hazard. Through bolts are stronger but increase that hazard.
10. Wood treated with a chemical preservative is recommended for stadium-seat planking. Waterborne preservatives and selected pentachlorophenol solutions or water-repellent preservatives are suitable because most of them do not discolor the wood, nor have an odor. The treated wood, moreover, can be finished or painted like untreated wood.
11. The Select grades of lumber provide better seating material than Common lumber, but cost more. The Common grades of some species are satisfactory when used on a solid substructure.
12. Slat seats will probably hold position better than one-piece board seats.
13. Avoid wet or green lumber. Use lumber kiln dried or air seasoned to a moisture content suitable for that of the local atmospheric conditions. A moisture content of 12 to 15 percent generally should prove correct.

Table 1.--Average strength properties of timbers (For clear wood only)

Species	Composite strength values			
	(comparative figures) ¹			
	Bending strength:	Stiffness:	Hardness:	Shock resistance
Baldcypress.....	79	136	52	76
Douglas-fir:				
Coast type.....	90	181	59	81
Inland Empire type.....	80	159	58	72
Rocky Mountain type.....	75	142	52	67
Fir, white ²	72	141	41	66
Larch, western.....	89	153	64	81
Oak:				
Commercial red.....	101	168	103	139
Commercial white.....	99	149	109	125
Pine:				
Longleaf.....	106	189	76	103
Shortleaf.....	97	170	68	111
Ponderosa.....	65	112	41	58
Redwood.....	90	134	59	70
Spruce ³	71	136	42	71
Yellow-poplar.....	71	135	40	58

¹From U. S. Dept. Agr. Tech. Bull. 158.

²Average of four species: Abies grandis, A. nobilis, A. amabilis, and A. concolor.

³Average of red, white, and Sitka spruce.

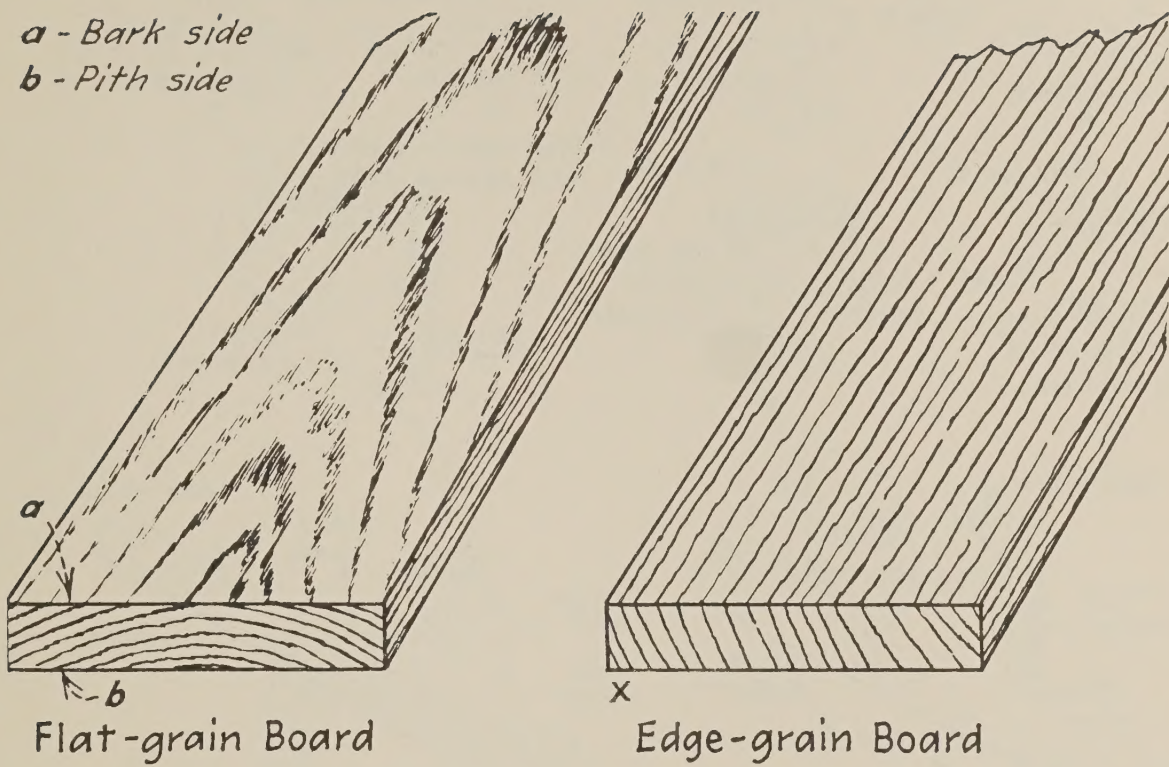


Figure 1. --A flat-grain board, where a indicates the bark side and b the pith side, and an edge-grain board, where x represents overhang.

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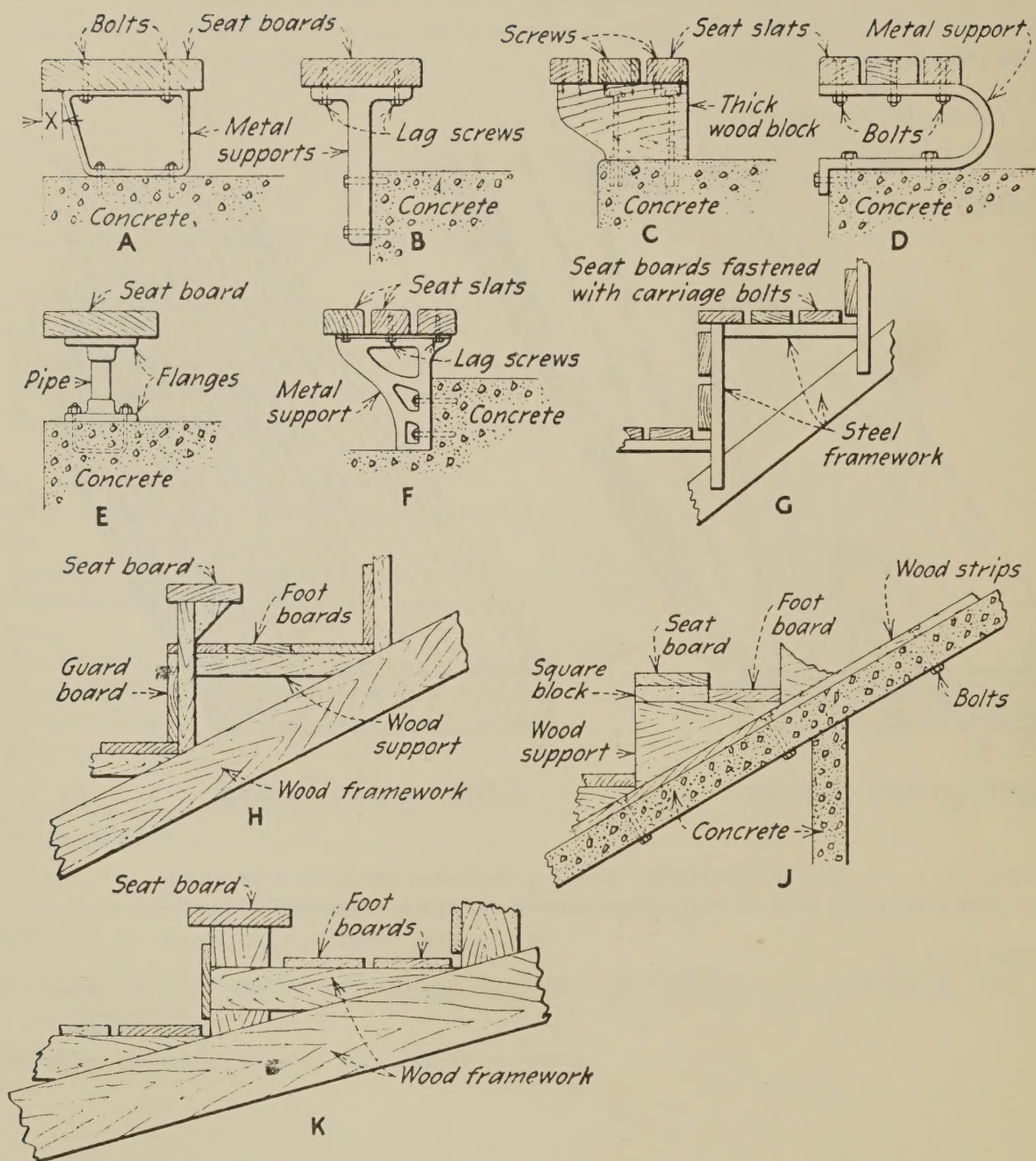


Figure 2. --Supports and fastenings for wood seats.

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